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Geology and Oil Possibilities of the Illinois Basin

By J. Marvin Weller

INTRODUCTION

There is no publication which presents in a general although comprehensive way an account of the stratigraphy, the structural history, and the oil and gas occurrences in Illinois. Many of the facts regarding the general geology of the State are well known to geologists who have worked in this area but the gathering together of such information by one unacquainted with all of Illinois would require the expenditure of much time and labor in the study of many more or less unrelated reports and maps. Furthermore, the Illinois State Geological Survey is in possession of much additional information, as yet unpublished, which is therefore not available to the public in convenient form.

The following address was delivered before the Fourth Annual Petroleum Conference of Illinois-Indiana held in Robinson, Illinois, on June 6th, 1936. It presents a brief summary of the more pertinent facts of interest to the petroleum industry and general conclusions drawn therefrom. Of the accompanying maps and diagrams only figures 2 and 4 were prepared especially for this conference. The others were originally made in 1926 for other purposes but have not previously been published. It is now known that some of the correlations employed in the original studies are erroneous and much new information not available when these maps were prepared is now at hand. These maps, therefore, are much generalized and are inaccurate in certain details. They do, however, present an adequate picture of the general conditions prevailing in the basin and if not relied upon for details they may be studied to advantage.

One particular error in these maps must be pointed out. The probable miscorrelation of a coal reached by a long abandoned mine shaft at Mattoon in Coles County is responsible for the bulging of the contours on the southwest flank of the LaSalle anticline in this vicinity. It is now believed that the flank of the anticline extends with fairly uniform slope straight across this area.

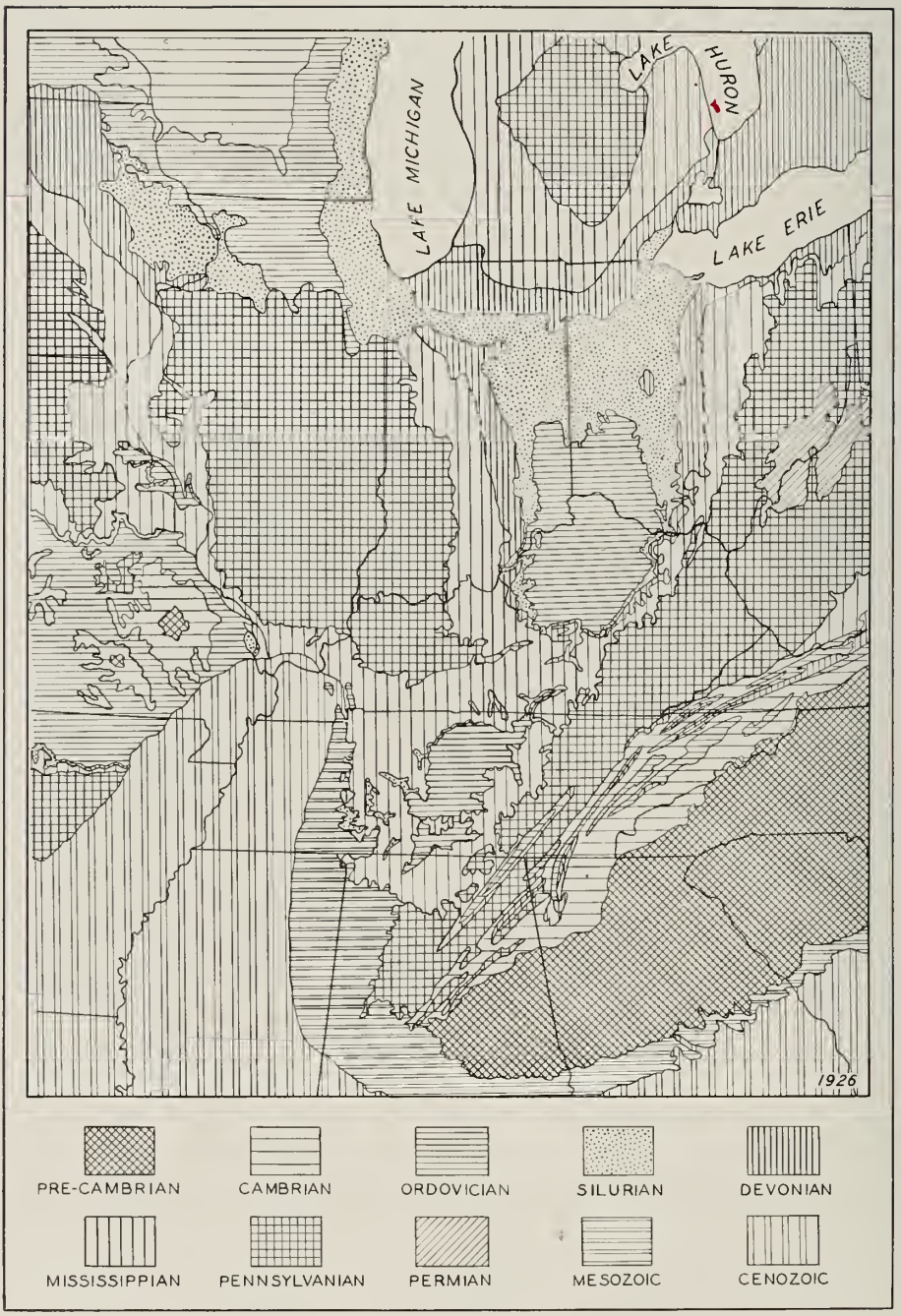


FIG. 1.—GEOLOGICAL MAP OF EAST CENTRAL UNITED STATES

The present very active interest in the oil possibilities of the Illinois basin has brought to the Survey many requests for just such information as is presented in this paper. It is obvious that this discussion will be of greatest value if it is published immediately. It is therefore presented with a series of unrevised maps because if these were to be brought up to date considerable delay would be unavoidable.

THE ILLINOIS BASIN

The existence of a great basin occupying most of Illinois and the adjacent portions of southwestern Indiana and western Kentucky has been known for a century. It is clearly shown by the outcrops of the various geological formations which occur in more or less concentric zones around the large central area of Pennsylvanian or "Coal Measures" rocks (Fig. 1). The observation of rock outcrops, however, has been of little service in determining details of the structure within this basin because much of Illinois is covered with thick deposits of glacial drift so that outcrops are rare or absent in many areas, because until recently the Pennsylvanian rocks were not well enough understood to permit satisfactory correlation from place to place, and because of great buried unconformities and much change in the thicknesses of formations so that the structure of the underlying formations is not closely reflected in the structure of the surface beds. A general knowledge of the structure within this basin has, however, been slowly accumulating in the last thirty years as the result of drilling in the search for oil and gas.

Plate I shows in a generalized way by structure contours on the base of the New Albany shale the form of the Illinois basin. This map is based entirely upon drill records. The New Albany shale is the thick black or brown shale, often termed Devonian black shale, which lies below the Mississippian limestones and above the limestones and dolomites of the Devonian and Silurian systems. In many Illinois reports it has been termed Sweetland Creek shale. Few wells in the central and southern parts of the basin have penetrated to this horizon and its position here has been estimated from the known position of other more shallow beds. Certainly the structure is not as simple as here shown but the comparatively small number of well records and the large contour interval of 100 feet does not permit the determination and representation of the numerous irregularities that are doubtless present.

The most important structural features of the Illinois basin are the LaSalle anticline, which in the north divides the basin into two unequal parts, and the Rough Creek or Shawneetown fault zone that cuts across it to the south.

Oil was first discovered in important quantities in Clark County, and the main southeastern Illinois fields were rapidly developed from Clark County southward to Wabash County. Smaller fields were discovered in

southwestern Indiana, western Kentucky, and southwestern Illinois along the flanks of the basin, mainly on small anticlines or domes.

The anticlinal theory for the accumulation of oil, which proved to be so successful in the development of the Mid-Continent region from 1910 to 1920, suggested that the oil had migrated up out of the central part of the Illinois basin to be trapped in these marginal structures, and consequently the central part of the basin was generally regarded as unfavorable territory and was largely shunned by conservative prospectors.

THE MICHIGAN BASIN

The state of Michigan occupies a structural basin similar to but somewhat smaller than the Illinois basin, from which it is separated by a broad branch of the Cincinnati anticline known as the Kankakee arch. The discovery of oil in 1928 near Mt. Pleasant in the very central part of the Michigan basin and the subsequent development of the most productive oil fields of that state proved that oil does not necessarily migrate up out of such a basin if suitable reservoir conditions are locally present. As a result of this discovery serious interest in the oil possibilities of the central part of the Illinois basin began to appear.

The structure of the Michigan basin, as shown by a map published by the Michigan Geological Survey,[1] appears to be more complicated than in Illinois, but this may be because the Michigan basin is not so deep and because many more wells have been drilled to the contoured horizon so that it is possible to construct a more detailed and accurate map of Michigan than of Illinois.

AGE OF THE BASINS

The Michigan basin is a very old structure that started to form very far back in geologic time and has subsequently slowly grown deeper. As a result, most of the formations in Michigan are thickest in the central part of the basin and thin out in all directions. There does not appear to have been any one particular time at which the greater part of this structure was developed.

In this respect the Illinois and Michigan basins differ. The northeastern and western boundaries of the Illinois basin are as old, geologically, as the boundaries of the Michigan basin, and from them most of the formations thicken inward and southward. They do not thin southward from the central part of the basin, however, but continue to thicken in this direction and it is obvious that the Illinois basin was for a very long time only the northern part of a much larger basin that formerly extended an unknown distance

[1] R. B. Newcombe, Oil and Gas Fields of Michigan; Michigan Geol. Survey Publication 38, Geol. Series 32, 1933, Plate 3.

farther south down the present Mississippi valley. The southern boundary of the Illinois basin was formed by a comparatively sudden series of earth movements that occurred after all of the rocks which now occupy the basin had been formed.

FIG. 2.—CROSS-SECTIONS OF ILLINOIS BASIN

P—Pennsylvanian (dotted line shows position of coal No. 6)
UM—Upper Mississippian
LM—Lower Mississippian
D—Devonian
S—Silurian
O—Ordovician

PENNSYLVANIAN OVERLAP

Also a very important part of the structure of the Illinois basin was developed at the end of the Mississippian period. At this time the borders of the basin were upraised and the LaSalle anticline was folded. These upraised areas were then worn down by erosion and subsequently the Pennsylvanian beds were deposited so that they cut across and overlap to the north 3,000 feet of strata along one of the greatest unconformities in the central United States. The overlap is shown in the accompanying cross-sections (Fig. 2). From south to north Pennsylvanian beds truncate the Upper Mississippian, Lower Mississippian, Devonian, and Silurian and finally rest upon Ordovician strata. From southeast to northwest there is similar but less extensive overlap. Figure 3 shows the overlap of the Pennsylvanian upon older formations throughout the entire Illinois basin. Deepening of the Illinois basin continued slowly but persistently through Pennsylvanian time and later.

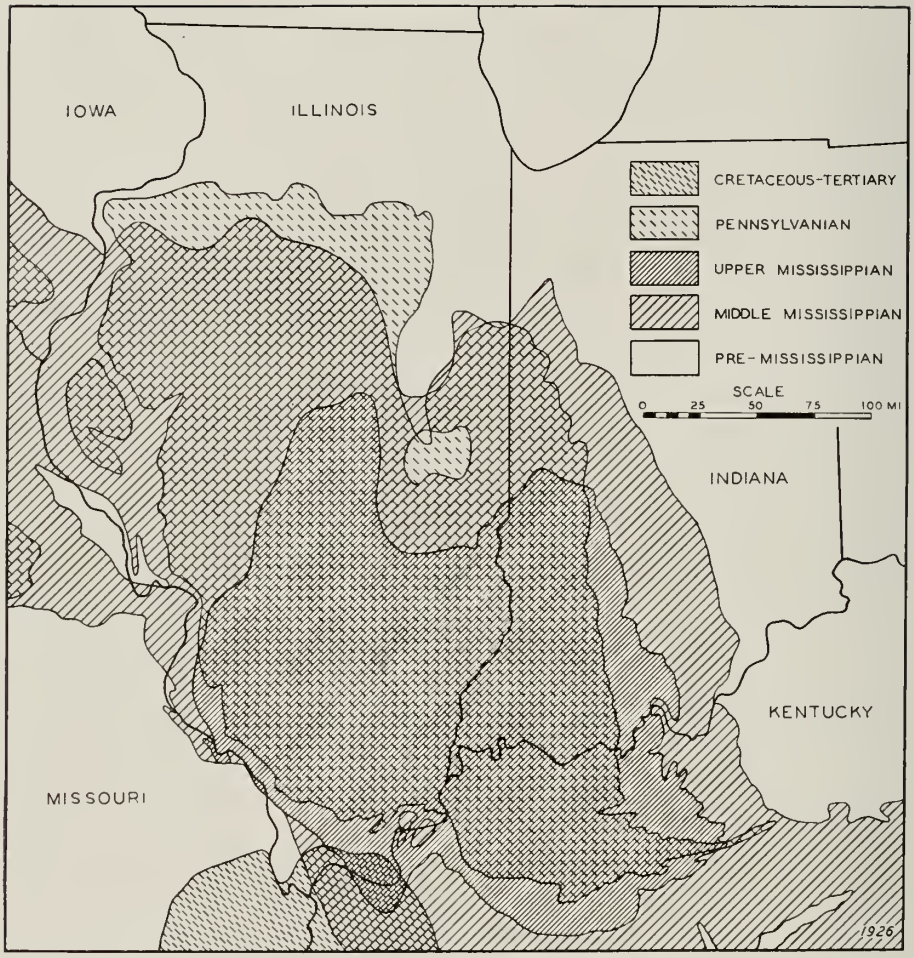


FIG. 3.—MAP SHOWING PENNSYLVANIAN OVERLAP IN THE ILLINOIS BASIN

STRATIGRAPHIC SECTIONS

Although structurally the states of Illinois and Michigan have much in common, the succession of geologic formations is quite different (Fig. 4). In the first place the glacial drift or surface clays are much thinner in Illinois, and as a result rock outcrops are much more abundant than in Michigan. The Pennsylvanian rocks are of similar character in the two states but attain much greater thickness in parts of Illinois than anywhere in Michigan. The Mississippian rocks are of about equal thickness. The Chester or Upper Mississippian series of Illinois and possibly the underlying Ste. Genevieve

FIG. 4.—GENERALIZED COLUMNAR SECTIONS FOR ILLINOIS AND MICHIGAN BASINS SHOWING PRINCIPAL HORIZONS OF OIL AND GAS PRODUCTION

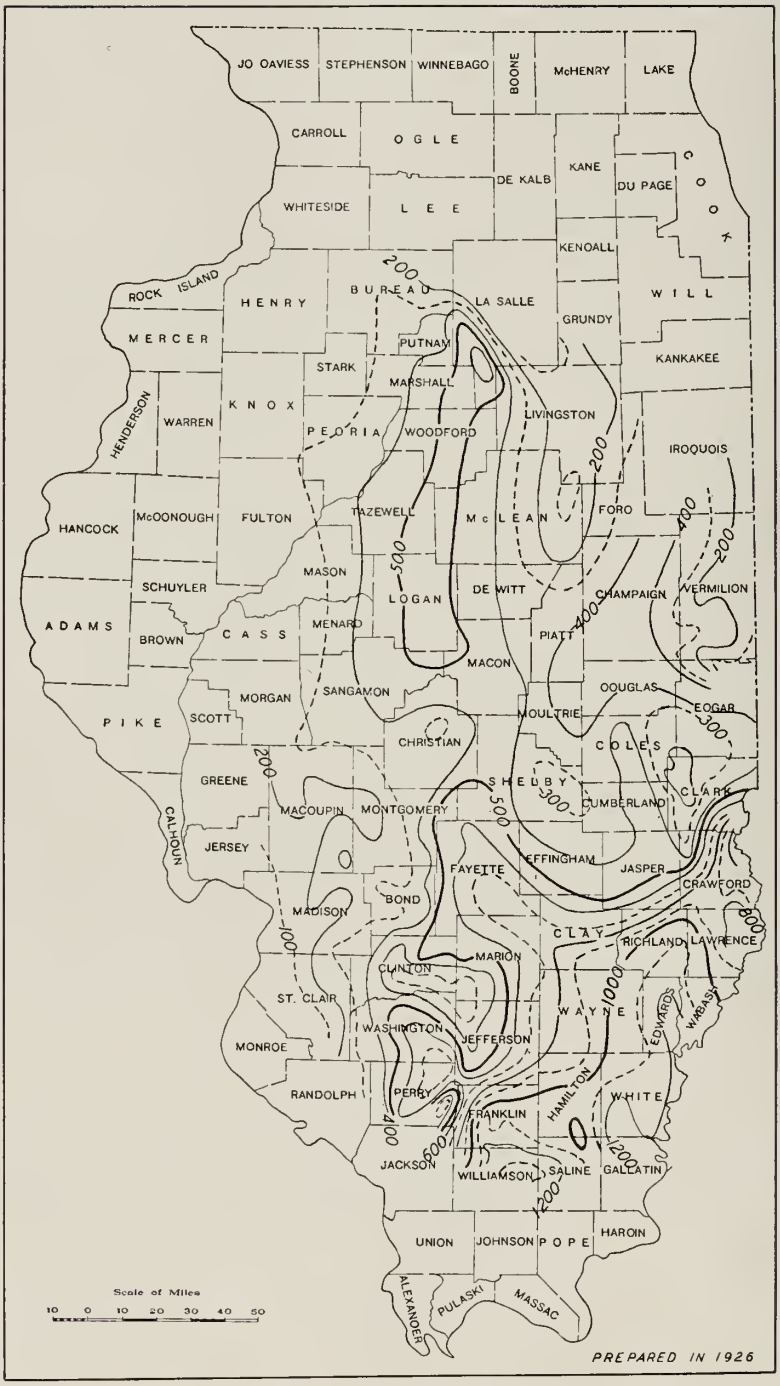


FIG. 5.—ISOPACH MAP SHOWING THE THICKNESS OF PENNSYLVANIAN BEDS BELOW COAL NO. 6

For correction see explanation below Plate I

limestone are not represented in Michigan and the Lower Mississippian limestones of our state are therefore represented there by a much greater thickness of mainly shaly and sandy rocks. The Devonian system is comparatively poorly developed in Illinois except in the south, and in much of the basin area there appear to be no beds equivalent to the thick Middle and Lower Devonian limestones of Michigan. The Silurian system is also much thicker in Michigan than in Illinois and Illinois has nothing comparable to the thick Upper Silurian of Michigan. The Upper and Middle Ordovician sections of the two states are, however, quite similar.

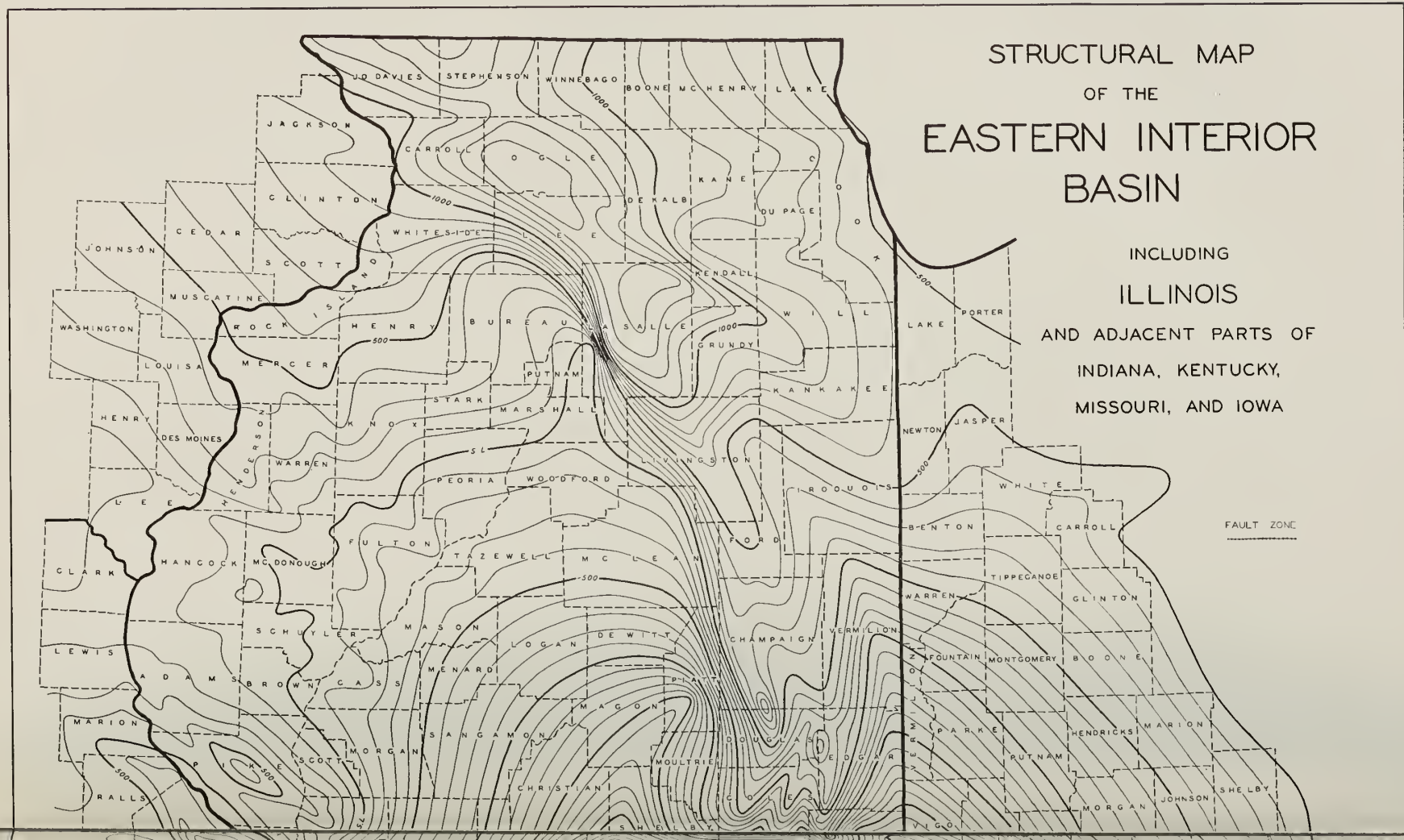
OIL-BEARING BEDS

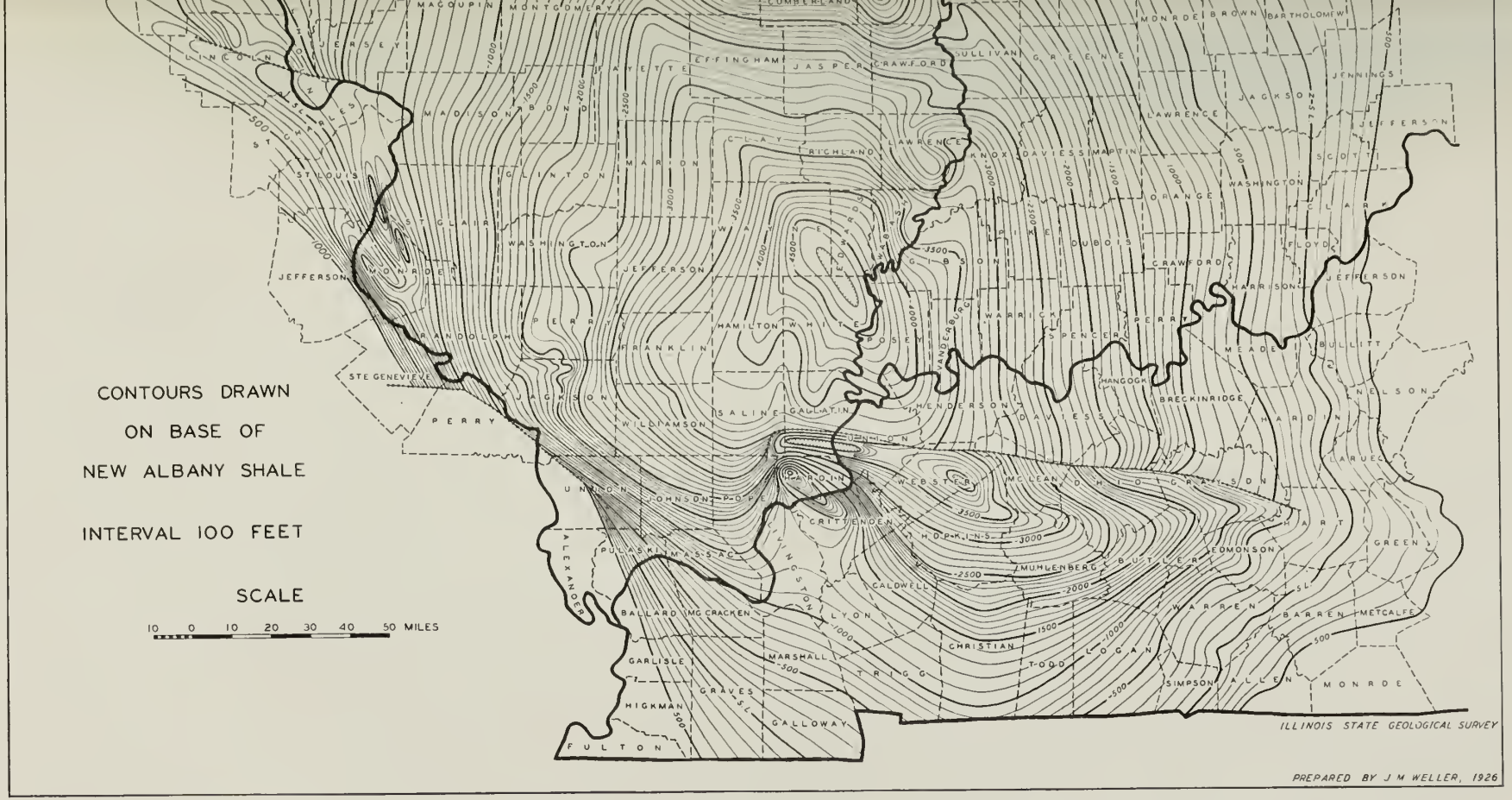
Figure 4 also shows the oil and gas bearing horizons of the two basins. Productive oil zones are shown by solid dots and shows by open circles. The fact to be noted here is that some of the most productive beds of the Illinois basin are not present in the geological section of Michigan, and conversely the most productive beds of Michigan are unrepresented in much of Illinois.

More than half of the oil production of Illinois has come from sands near the base of the Pennsylvanian system such as the Bridgeport, Buchanan and Robinson sands. Similar beds are unproductive in Michigan. Over half of the remainder of Illinois' oil has come from sands in the Chester series of which the Cypress and Bethel sandstones are by far the most important. These are the Kirkwood, Carlyle, Tracy, and Benoist sands. No Chester beds are present in Michigan. These Pennsylvanian and Chester sandstones account for nearly 90 per cent of the oil of Illinois. Most of the remainder has come from porous limestone in Lower Mississippian formations. The McClosky horizon in the upper part of the Ste. Genevieve limestone is by far the most important and has given the wells of largest initial production ever brought in in this state. The Ste. Genevieve, like the Chester, appears also to be missing in Michigan.

The St. Louis limestone is productive in the Bowling Green field of Kentucky and in the Westfield pool of Illinois at a horizon approximately equivalent to the shallow gas sands of central Michigan. The Illinois and Kentucky production, however, is from porous limestone and that of Michigan is from true sandstone.

The first important oil horizon of Michigan is porous limestone in the upper part of the Traverse group. This corresponds approximately to the Devonian limestone production in the Martinsville pool of Illinois, the Siosi pool of Indiana, and the Corniferous production of western Kentucky. The greater part of the oil of Michigan has been obtained from porous beds in the Dundee and Detroit River limestones. Beds of similar age may be present in the southern part of the Illinois basin but if so they are not known to be oil bearing. No Trenton production has been obtained in Michigan, but


STRUCTURAL MAP
OF THE
EASTERN INTERIOR
BASIN
INCLUDING
ILLINOIS
AND ADJACENT PARTS OF
INDIANA, KENTUCKY,
MISSOURI, AND IOWA
FAULT ZONE
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
MC HENRY
LAKE
JACKSON
CARROLL
OGLE
KANE
COOK
CLINTON
DE KALB
DU PAGE
CEDAR
WHITESIDE
JOHNSON
SCOTT
KENDALL
MUSCATINE
ROCK ISLAND
HENRY
BUREAU
LA SALLE
WILL
LAKE
PORTER
WASHINGTON
GRUNDY
LOUISA
MERCER
PUTNAM
KANKAKEE
STARK
MARSHALL
HENRY
DES MOINES
KNOX
HENDERSON
NEWTON
JASPER
WARREN
LIVINGSTON
PEORIA
WOODFORD
IROQUOIS
WHITE
LEE
FULTON
TAZEWELL
MC LEAN
FORD
BENTON
CARROLL
CLARK
HANCOCK
MC DONOUGH
TIPPECANOE
WARREN
CLINTON
SCHUYLER
MASON
CHAMPAIGN
VERMILION
LEWIS
LOGAN
DE WITT
FOUNTAIN
MONTGOMERY
BOONE
ADAMS
BROWN
CASS
MENARD
PIATT
MACON
PARKE
HENDRICKS
MARION
MARION
SANGAMON
DOUGLAS
EDGAR
PUTNAM
SCOTT
MORGAN
MOULTRIE
CHRISTIAN
COLES
JOHNSON
SHELBY
CRAWFORD
CLAY
RICHLAND
EFFINGHAM
FAYETTE
VIGO
SHELBY
500
1000
75



NOTE: Since this map was prepared in 1926 a new correlation for a coal beneath Mattoon in Coles County affects the interpretation of the structure on the southwest flank of the LaSalle anticline in the west part of Coles County and in the adjoining parts of Moultrie, Shelby, and Cumberland counties, Illinois. This eliminates the southward and southwestward bulge in contours –500 to –2500. It is now believed that the flank of the anticline extends with fairly uniform slope straight across from southwestern Champaign County to Clark County.

The revised interpretation applies to all isopach and structure maps in this report.

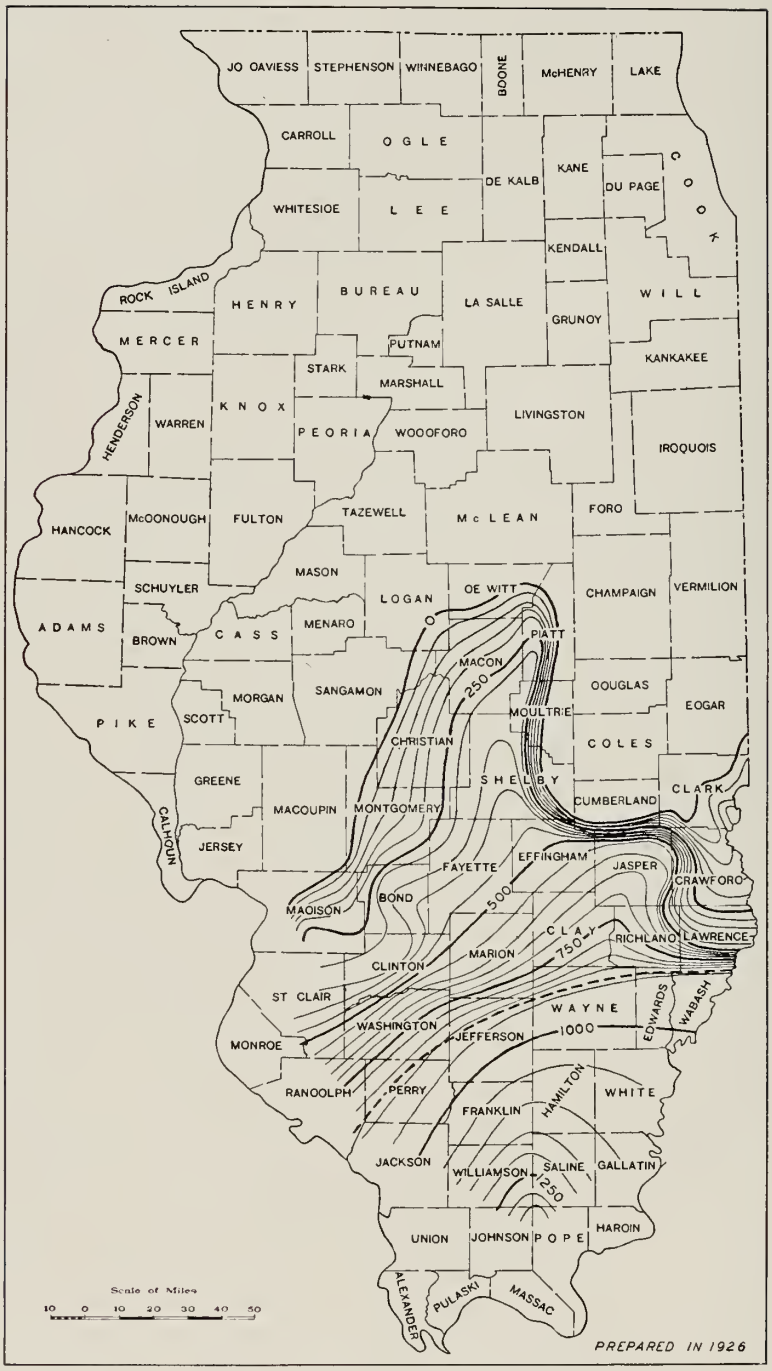


FIG. 6.—ISOPACH MAP SHOWING THE THICKNESS OF THE UPPER MISSISSIPPIAN STRATA

For correction see explanation below Plate I

only a few wells have been drilled this deep except around the edges of the basin.

The foregoing comparison of the stratigraphic sections and productive beds in the Illinois and Michigan basins clearly brings out the fact that there are many more potentially productive horizons in the Illinois basin than there are in Michigan, and the available geologic data give rise to the hope that as yet undiscovered oil pools in the Illinois basin may far outrank anything that has been discovered in Michigan.

PENNSYLVANIAN PRODUCTION

An analysis of the geologic conditions that account for the trapping of oil in the various productive horizons of Illinois suggests that our oil pools may be classified into three groups. First and most important are pools in sands near the base of the Pennsylvanian system. Most Pennsylvanian sandstones are very irregular in distribution and thickness. Some of them are of the shoe-string type and occupy definite long narrow channels. The Pennsylvanian system in general, and the lower part in particular, is much thicker in southern Illinois than farther north. This thickening to the southward is caused to a considerable extent by the greater number and thickness of the sandstone members. Figure 5 shows by 100-foot contours the thickness of the Pennsylvanian beds below coal No. 6. It shows a rapid thinning of this part of the section to the north in Crawford County, where the basal Pennsylvanian sands are so productive, and east of the Duquoin anticline, particularly in Franklin County. Possibly other areas of rapid thinning that have not yet been detected occur in the intermediate area. In these areas we might expect to find the lower Pennsylvania sandstones lensing out up the dip, thus forming ideal traps for oil.

CHESTER PRODUCTION

Second there are the Chester sands. These are continuous and rather uniform formations and for the most part, therefore, the accumulation of oil in them is probably dependent upon structure. Closed structures in these beds, particularly the Cypress and Bethel sandstones, anywhere in the Illinois basin or upon its flanks would be very favorable sites for testing. Figure 6 shows the thickness of the Chester series by 50-foot contours. South of the dashed line practically the complete Chester section is present but to the north erosion removed greater and greater thicknesses of these beds and the Pennsylvanian overlaps onto lower and lower Chester formations. If a Chester sandstone, truncated by this unconformity, were overlain by impervious Pennsylvanian beds a trap suitable for the accumulation of oil might be formed. If, on the other hand, the Chester sand were capped by pervious Pennsylvanian beds, any oil that might have been contained in the

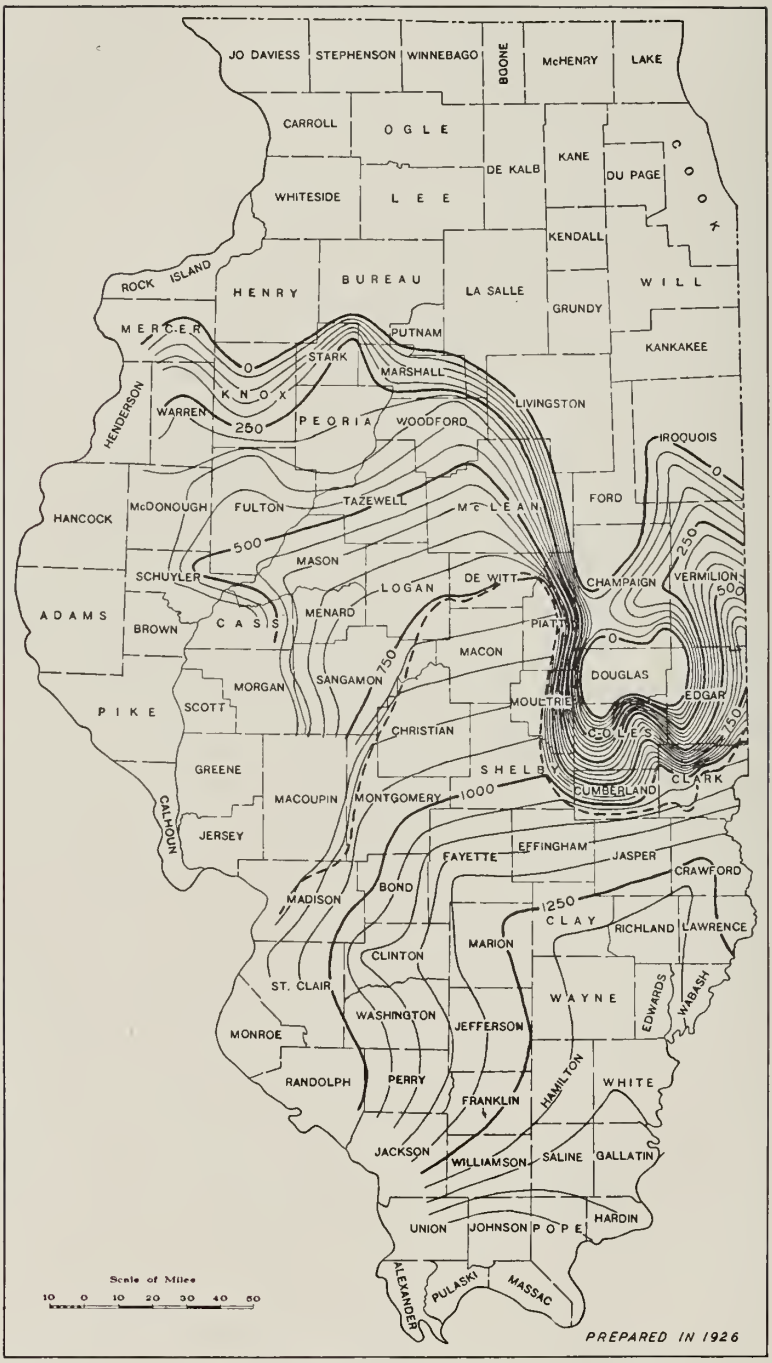


FIG. 7.—ISOPACH MAP SHOWING THE THICKNESS OF THE LOWER MISSISSIPPIAN STRATA

For correction see explanation below Plate I

Chester sand might migrate upward into the Pennsylvanian system to be later trapped in a lenticular sand body above. The rapid overlap of the Chester series in northwestern Crawford County where the lower Pennsylvanian beds are thinning rapidly may in part account for the particular concentration in this area of important production from the lower Pennsylvanian sands.

LIMESTONE PRODUCTION

Third and last there are the oil pools accumulated in porous limestone. Most limestones are dense and nonporous formations, and many geologists believe that the porosity that has allowed oil to accumulate in certain limestones is the result of weathering and solution of these beds at some remote time when they were at the surface, and that the traps were formed by the subsequent burial of such weathered surfaces by impervious beds. In other words, the accumulation of oil in limestones has been correlated with unconformities. In Illinois there are a number of unconformities at which limestones are overlain by more or less impervious beds. For example, Figure 7 shows the thickness of the Lower Mississippian series, which is composed principally of limestone. So far as is known, younger beds everywhere lie unconformably upon these limestones, and north of the dashed line which marks the maximum extent of the Chester rocks, the unconformity becomes more and more important with the overlapping of Pennsylvanian beds onto lower and lower horizons. Such unconformities, in Illinois at least, cannot be relied upon, however, for new production. The Lower Mississippian has been drilled at many places but the only production of importance obtained from these limestones is in the southeastern fields. Also the Silurian dolomites are everywhere overlain by unconformable beds. This unconformity is an important one because a considerable thickness of beds belonging at this position and known elsewhere in the United States, in Michigan for example, are missing in Illinois, but no production has ever been obtained from this horizon anywhere in the Illinois basin.

FAVORABLE HORIZONS

Although it is not possible to absolutely condemn any particular bed as a possible source of new oil production in the Illinois basin, the facts and conclusions that have been presented strongly suggest that certain beds are much more likely to be productive than others and the search for favorable geologic conditions in these particular beds should be the primary objective in the prospecting of unproved territory. In the light of present knowledge, the two outstanding groups of beds are the lenticular sandstones in the lower part of the Pennsylvanian system and the sandstone formations of the Chester series, particularly the lower ones.

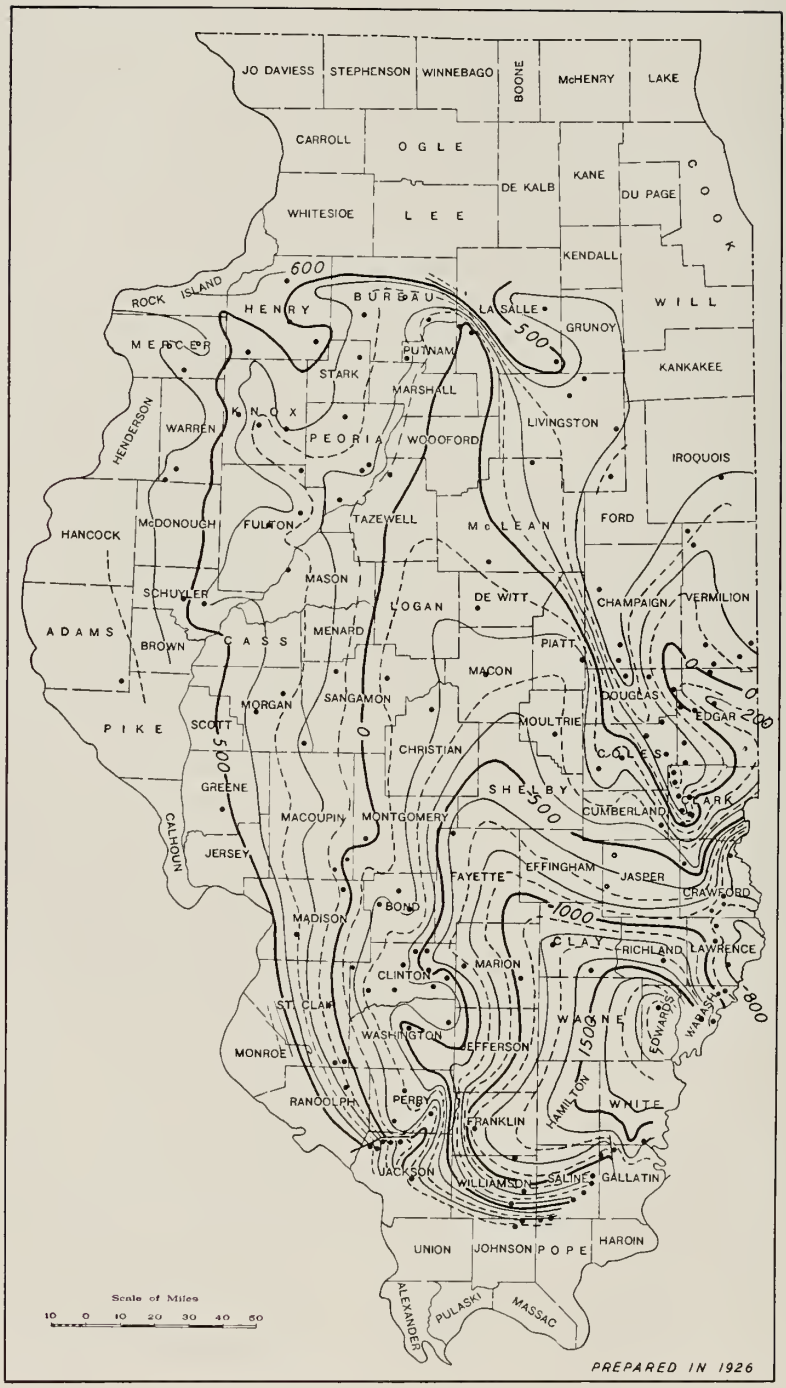


FIG. 8.—CONTOUR MAP SHOWING THE BASE OF THE PENNSYLVANIAN SYSTEM

For later maps of central portion of basin, see Illinois Geological Survey Rept. Investigations No. 40, Fig. 2

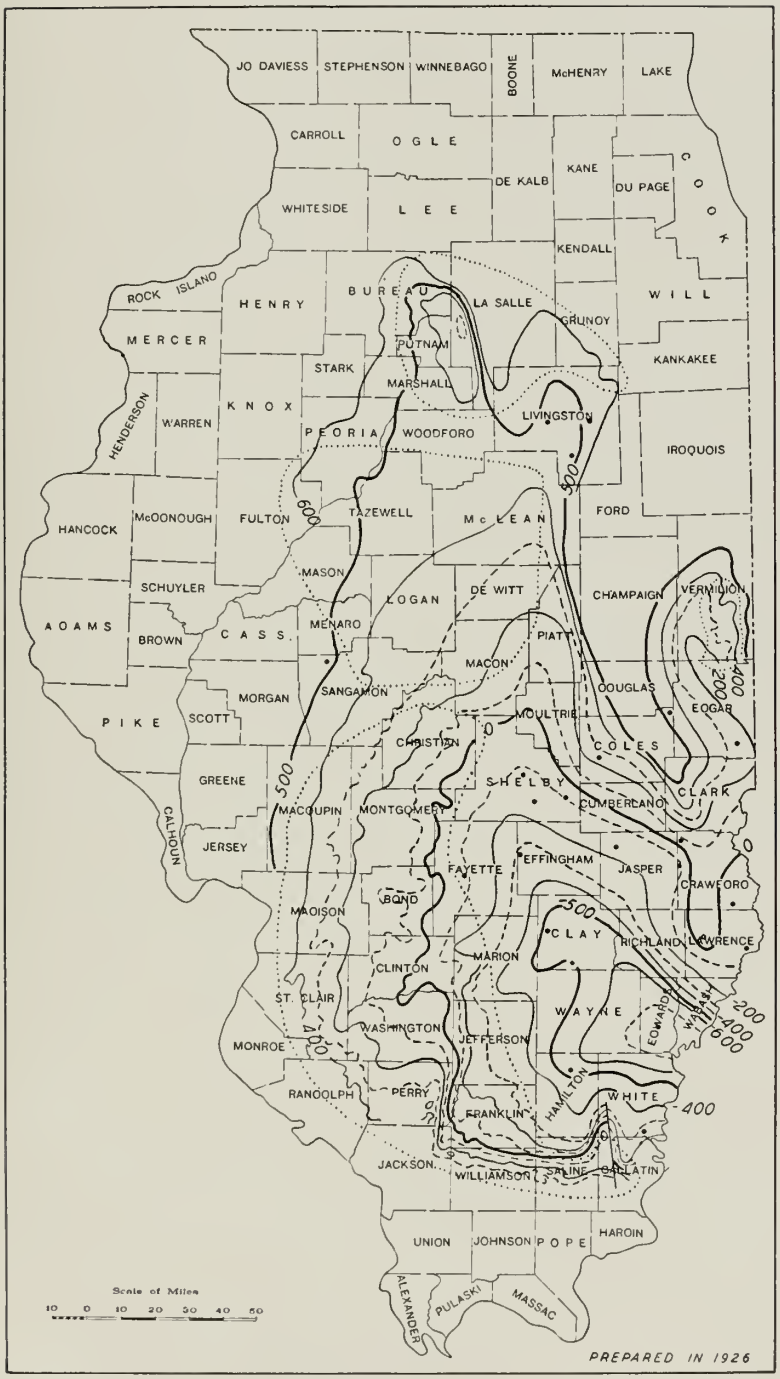


FIG. 9.—STRUCTURE CONTOUR MAP OF COAL NO. 6
For correction see explanation below Plate I

The wedging out of lower Pennsylvanian sandstones on the east flank of the Duquoin anticline, on the southwest flank of the LaSalle anticline, and in the intermediate area does not appear to be discoverable by surface geological studies. These beds occur at comparatively shallow depth and their adequate investigation will require a liberal and intelligently directed drilling program. Production from the Chester sands appears possible wherever closed structures occur, either in the central part of the Illinois basin or upon its flanks. Some indication of such structures may be obtained by surface studies.

SURFACE AND SUBSURFACE STRUCTURE

The Illinois State Geological Survey is conducting a comprehensive study of our Pennsylvanian rocks and it is now possible to identify, correlate, and determine the structure of the outcropping beds throughout much of the Illinois basin. It is known, however, that many of the dips observed on outcropping Pennsylvanian rocks have been produced by inequalities of deposition and by differential compaction rather than by actual folding, but if indications of folding can be found, such structures should continue downward to a great depth with modifications from formation to formation. Because downwarping of the Illinois basin has been progressing at varying rates since very early in geological time, it is quite probable that some structures marked by gentle dips at the surface will be found to become progressively steeper below. Figures 8 and 9 and Plate I show how the inclination of the beds into the main part of the Illinois basin from the west, north, and east becomes more gentle at the higher horizons. Plate I shows the amount of folding that has occurred since the beginning of Mississippian time. Figure 8 shows the position of the Pre-Pennsylvanian unconformity but because of the erosion that occurred after the folding at the close of the Mississippian period a nearly level surface was produced and this map, therefore, shows the amount of folding that has taken place since the beginning of Pennsylvanian time. Figure 9 shows the structure of coal No. 6 or the amount of folding that has taken place since the deposition of this bed. The structure of the beds becomes progressively more gentle as the surface is approached except on the southern flank of the basin, and the structure of the surface beds is even more gentle than the structure of coal No. 6. In contrast to this, however, the southward thickening of the beds results in the steepening of the north dips in southern Illinois from lower to higher beds.

Throughout the greater part of the basin in Illinois, underlying structures are probably reflected by broader and more gentle surface structures. The distinguishing of such structures from the local irregular dips in surface beds that have not been produced by folding is of course much to be desired. At present, unfortunately, it is impossible to arrive at any hard and fast method by which true folds may be certainly identified and good judgment

combined with experience must be relied upon. In a general way it seems to be fairly safe to assume that more or less local dips of more than ordinary steepness or gentle dips of more than usual constancy are direct indications of folding. It is entirely possible, however, that subsurface structures exist which find no expression at the surface. Because of the structural history of the basin it seems probable that east-west trends would be more likely to show at the surface than north-south trends. On the southern flank of the basin any decrease in the inclination of the surface beds, or terracing, might pass downward into deeper structures of more promising configuration.

SURFACE STUDIES

Surface studies carried on by competent geologists experienced in the type of work necessitated by conditions in Illinois are certainly of value. Such work is comparatively inexpensive and, although not certainly conclusive in itself, will furnish the basis for concentrating in the most promising areas the much more costly methods of exploration such as drilling for structure or systematic seismograph surveys.